EMS Annual Meeting Abstracts
Vol. 16, EMS2019-957, 2019

ADS-B Interferometry - A new method of measuring atmospheric refractivity

Malcom Kitchen (1) and Chris Brunt (2)
(1) Observations R&D, Met Office, Exeter, EX1 3PB, UK, (2) Dept. of Astrophysics, University of Exeter, EX4 4QL, UK

Humidity can vary significantly over short time and space scales, but is difficult and expensive to measure directly. In-situ measurements are currently limited mainly to those from weather stations and a smaller number of radiosondes and aircraft. These data are inadequate for resolving the 3-dimensional structure. For this reason, methods have been developed in recent years for the measurement of atmospheric refractivity, which has a strong dependence upon humidity and can be an effective substitute in numerical weather prediction (NWP) model assimilation. A largely opportunistic technique for acquiring additional refractivity information in introduced here, that is complementary to the existing methods. It is envisaged that simple two-element interferometers could be sited on hill tops to measure the angle-of-arrival (AoA) of radio transmissions that have undergone measurable bending by the atmosphere. The radio transmissions are the 1090 MHz ADS-B transmissions which all commercial aircraft are mandated to broadcast for air traffic and anti-collision purposes. The signals will undergo measurable bending a) as aircraft “rise” or “set” over the radio horizon (which will normally occur at ranges of $\sim$400km for aircraft at cruise altitude) or b) at shorter ranges for aircraft taking off or landing. ADS-B broadcasts conveniently contain the aircraft location that is essential for the bending angle calculation. Preliminary sensitivity studies suggest that in order to detect meteorologically significant changes in refractivity, AoAs of $\lesssim 2^\circ$ above the horizon will need to be measured with an accuracy of $\sim 0.01^\circ$ or better. This in turn will require an interferometer with a clear horizon and a (vertical) baseline of $\sim$10 m. In any operational implementation, it is envisaged that interferometers could be mounted on weather radar towers to avoid the need for a special frame to provide the necessary structural stability. The technique could be implemented anywhere in the world with a usable density of civil air-traffic. For example, $\sim 10^4$ aircraft enter or leave UK airspace each day, with similar numbers landing and taking off from UK airports. ADS-B messages are broadcast every few seconds, and could be received by any hill-top interferometer that has line of sight. There is then the potential to acquire $\sim 10^5$ –10^6 bending angle measurements per day for assimilation into NWP models. A prototype interferometer has been constructed using off-the-shelf Software Defined Radio (SDR) modules. Initial experiments with this interferometer will be described that suggest that the required precision in AoA measurement should be achievable at a relatively low cost. The next steps in development of both the practical implementation and in assessing the information content of the data are also outlined.